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Remote Measurement Utilizing NASA's Scanning Laser Doppler Systems

Volume 2 – Final Report

Laser Doppler Dust Devil Velocity Profile Measurement Program

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FOREWORD

This document was prepared by personnel in the Laser Systems Section of Lockheed's Huntsville Research & Engineering Center for NASA-Marshall Space Flight Center. The work described was accomplished under Contract NAS8-30971 and is presented as Volume II of two volumes. Volume I is entitled "Laser Doppler Wake Vortex Tracking at Kennedy Airport." The NASA-MSFC technical monitor and alternate monitor for this contract were James W. Bilbro, EB34, and Harold B. Jeffreys, EB34, respectively.

ACKNOWLEDGMENT

NASA personnel responsible for the success of the laser Doppler dust devil velocity profile measurement program were James W. Bilbro, G. D. Craig, Ronald W. George, Robert M. Huffaker, Harold B. Jeffreys, Peter J. Marrero and Edwin A. Weaver. Lockheed-Huntsville Personnel who contributed to the dust devil program included Michael C. Krause, Charles E. Craven, Edward J. Gorzynski, Bobby B. Edwards, Robert L. Chaney and Robert E. Howle.

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INTRODUCTION

In an effort to determine the major physical characteristics of tornadoes, a program was undertaken to measure analogous phenomena occurring in vertical vortices present in desert areas. These miniature tornadoes are referred to as "dust devils" and are essentially small tornadoes in which dust is entrained. As the surface temperature of desert terrain increases to 140F and above, vertical air currents are formed. These currents are somehow perturbed in such a fashion that flowfield characteristics change from purely vertical translational motion to a combination of translation and rotation prevalent in vortex structures (Fig. 1). The principal fluids involved are hot air and entrained dust particles.

Collection of data from these dust vortices had, until the present effort, been limited to photographic records and sparse temperature, pressure, electrical potential and velocity data obtained by sensors. According to Ives (Ref. 2)

> "Field data here presented (horizontal and vertical dust devil wind velocity data, temperature measurements, electrical charge data, and pressure measurements) are regarded as a second approximation, probable error being between 10 and 20%. Further observations, to a higher degree of accuracy, should be made as soon as instrument developments make them possible.
>
> "Field instruments now (1946) available which are sufficiently portable for use in areas where dust devils are plentiful are, in general, too slow in their responses, and too subject to dust damage, to permit greater data refinements."

Although various types of advanced instrumentation have been developed since 1946, not until laser Doppler velocimeter (LDV) systems were perfected was an instrument available capable of making accurate velocity measurements without perturbing the flow field. Having a remote data acquisition capability also reduces the susceptibility of equipment to high velocity particulate damage.

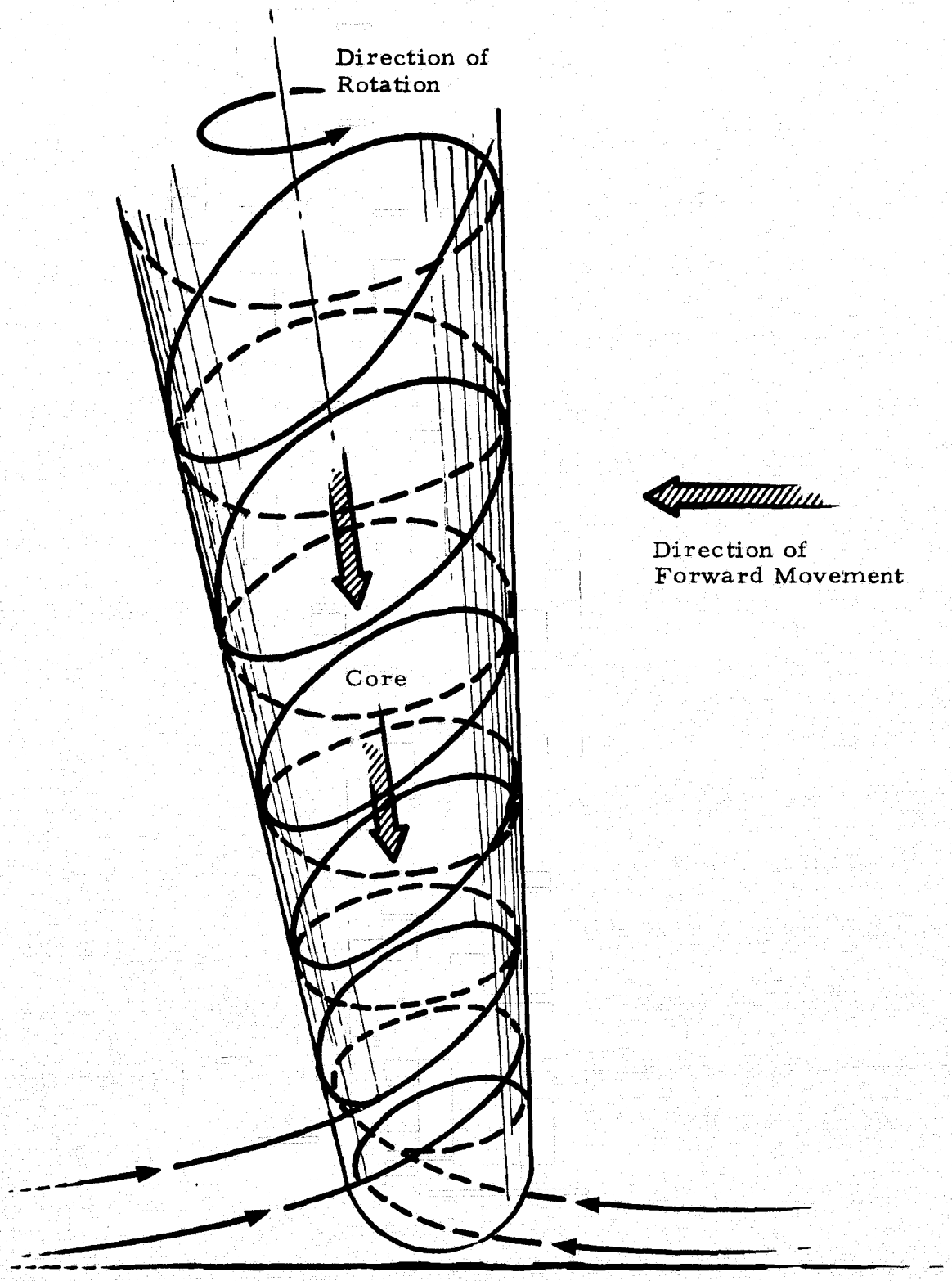


Fig. 1 - Dust Devil

SUMMARY

In the Spring of 1975, NASA initiated a program using the available LDV equipment to monitor and record velocity data over the entire vortex core. The LDV equipment is uniquely suited to this requirement due to its ability to measure fluid velocity at different spatial positions with good resolution and without perturbing the fluid flow as does an anemometer or balloon. A field engineering team from Lockheed-Huntsville, recently returned from measuring aircraft vortices for NASA at Kennedy International Airport in New York, was assembled to operate the test site. This support group was given the task of modifying the available equipment, preparing the test site, operating the equipment and in conjunction with NASA personnel, collecting and analyzing the data obtained.

Test site location was selected on the basis of records of previous dust devil occurences throughout the Southwest. The primary and secondary site locations were at positions of maximum previously recorded dust devil activity. The candidate sites were: (1) Gila Indian Reservation located just outside of Tempe, Arizona, near Phoenix, and (2) a backup site near Tucson, Arizona. Use of the primary preferred site was dependent on approval of access by the Indian tribal council. This approval was received just prior to the beginning of the test program.

This program was coordinated with a local scientist, Dr. Sherwood Idzo, who was familiar with the area, regions of high dust devil activity, and with the characteristics and behavior of the dust vortices. Dr. Idzo had collected considerable photographic data on this phenomenon over several years and provided valuable aid in this experimental endeavor. He had recorded their structure both with and without seeding with aerosol particles from smoke bombs. This technique allows visualization of these vortices in the cases

where they are almost invisible to the eye. This seeding is performed by sighting the dust devil, running toward it with a ready smoke bomb until within range, activating the smoke bomb (pulling the pin), and then inserting it into the base of the dust vortex. The smoke is then entrained in the flow field core and provides a visual display of vortex structure. Since most dust devils do not remain stationary, it is necessary to follow the dust devil on foot (usually at a rapid pace) until either the runner or the dust devil gives out or dissipates. Accomplishing this goal is further complicated by the fact that the ambient thermal conditions are usually above 100F. It was observed that smoke bomb operator failure occurred before a maximum of six "runs." Use of smoke bombs proved to be a useful technique for vortex visualization, especially for photographing the core at high altitudes. An alternate method of increasing dust devil visibility involved kicking dust into the core of the vortex.

The laser Doppler velocimeter system obtained velocity profile data on dust devils which were highly visible, such as those with large amounts of entrained particulate matter (dust, smoke) and also optically invisible thermal vortices.

TECHNICAL OBJECTIVES

Due to the extreme environmental conditions encountered at the test site and their effects on both equipment and personnel, a few details of the less critical proposed objectives were eliminated. An initial list of proposed technical objectives is given below:

1. Obtain V_{peak} across the dust devil versus time at constant elevation.
2. Obtain V_{peak} across the dust devil versus altitude versus time.
3. Obtain the wind velocity information in the vicinity of the dust devil when range of the dust devil is less than 1200 feet.
4. Measure the track of the dust devil with respect to the mean wind. Obtain video and photographic coverage to resolve the track. The site should be marked and measured appropriately to show up on movie and video coverage.
5. Measure the slant angle of the dust devil from the vertical, if the dust devil is tilted. This information can be resolved from data when in the full scanning mode.
6. Obtain movie and still photographic coverage of the dust devil from generation to decay.
7. Obtain daily (when operating) the winds aloft data from Luke Air Force Base.
8. Obtain daily, from the National Weather Service, copies of good photographs of weather maps. In particular:
   a. Pressure maps-charts especially for pressures from ground level to 10-15,000 feet — 700 mb level — maximum
   b. Temperature charts
   c. Cloud cover data
   d. Any localized weather data charts available
   e. Any other that may potentially be appropriate
   f. Obtain satellite photographs; high resolution; contact Kelly at MSFC and give him the times desired

g. Rawinsonde data

9. Measure velocities of the dust devil being generated.

10. Measure velocities of the dust devil decaying.

11. Obtain wind velocities in the azimuth scan mode with a translator in the system.

12. Obtain vertical wind field in the vicinity of a severe storm.

13. Obtain surface temperature. Cover thermometer with approximately one cm of dirt.

Special Considerations

1. Locate van at an angle so that system can look down parallel to the road in one extreme azimuth position. The field is approximately one mile long and 800 feet wide. This type of orientation should optimize scan volume.

2. When winds are monitored, record maximum range scan rate, maximum azimuth scan rate, and minimum total azimuth scan. The azimuth scan should cover an area approximately two dust devil diameters on either side.

3. If possible, obtain dust devil data with the translator in the system.

4. Place anemometers approximately ten feet above ground.

5. Record high speed data on all data runs.

6. Record wind information using Aerovane anemometer and Gill anemometer.

7. Place the wind anemometers in the azimuth scan area so that an independent check can be made of the LDV system.

8. Caution everyone to be especially observant as to possible causes of dust devil formation, i.e., tractors, cars going by, anything unusual.

9. Be observant for special wind conditions so that wind data can be taken.

PROGRAM GOALS

Additional goals of the program were to determine direction of vortex rotation, or whether rotation occurs both clockwise and counterclockwise. It was ascertained from both visual observation and photographic data that core rotation occurs in either direction. The rotational velocity of dust devils was obtained along with the absolute direction of rotation using an optical frequency translator. Net translational velocity of the vortex core can be obtained using angular azimuthal velocity data coupled with range data.

One major goal of the program was to obtain photographic records of dust devil creation, motion, and dissipation in the form of a color movie. This record would be used for study and also for program publicity. Dust devil and site photographs are given in Appendix A.

MODIFICATIONS AND LOGISTICS

Prior to the movement of the NASA laser van to the test site in Arizona, several modifications to the equipment were performed. The output pointing mirror was gimbaled along the vertical axis to incorporate an azimuth scan capability. The PDP 11 computer was moved from Van 1 to Van 2 along with the higher performance and reliability laser head in Van 1. Mirror modifications were performed on the telescope mount to allow placement of a TV camera to monitor azimuthal dust devil position. Due to the off-axis (in the vertical) positioning of this camera, visual dust devil tracking using the TV proved ineffectual. A video tape deck was also installed, but the system was not used in the actual tests. No computer software modifications were necessary to handle the dust devil data. Translated data could be recorded on the computer but not processed completely. As at Kennedy, data were also recorded on high speed digital tape.

For this project, instead of having a commercial shipping line move the van on a flat bed trailer, NASA personnel drove the van to the test site to minimize cost of shipping. Prior to the trip, everything in the van was tied down to eliminate equipment movement and possible damage. This new shipping procedure proved entirely satisfactory. Movement of the van took approximately three days each way. The van was sufficiently prepared to perform the test. However, due to the stringent time schedule, insufficient attention was directed toward modification of the van to prepare it for the hot, dry climate encountered. This situation will be remedied in any future test series.

TEST SITE LOCATION

The first test site was initially established adjacent to a plowed field on the Gila Bend Indian Reservation located as shown in Fig. 2. Specific directions to test site 1 are as follows:

> Drive south from Tempe, Arizona, (a suburb of Phoenix) on Interstate 10. To reach Gila River Indian Reservation, take Maricopa Road exit from Interstate 10 South, exit 162A. Go 3.15 miles South to a dirt road. You will notice a dip in the highway before the turnoff. Make a right turn onto the dirt road and travel approximately three miles West. Test site 1 is on the left-hand side of the road next to the cultivated field.

The second test site was also adjacent to a dusty graded field approximately four miles West of the first test site. It was necessary to relocate the van from site 1 to site 2 because the field being scanned at the first test site was being prepared for agricultural irrigation. As it turned out, this move was advantageous because site 2 produced more dust devils. For a detailed layout of sites 1 and 2, see Figs. 3 and 4. The van layout, which is similar to that used at Kennedy, is shown in Fig. 5.

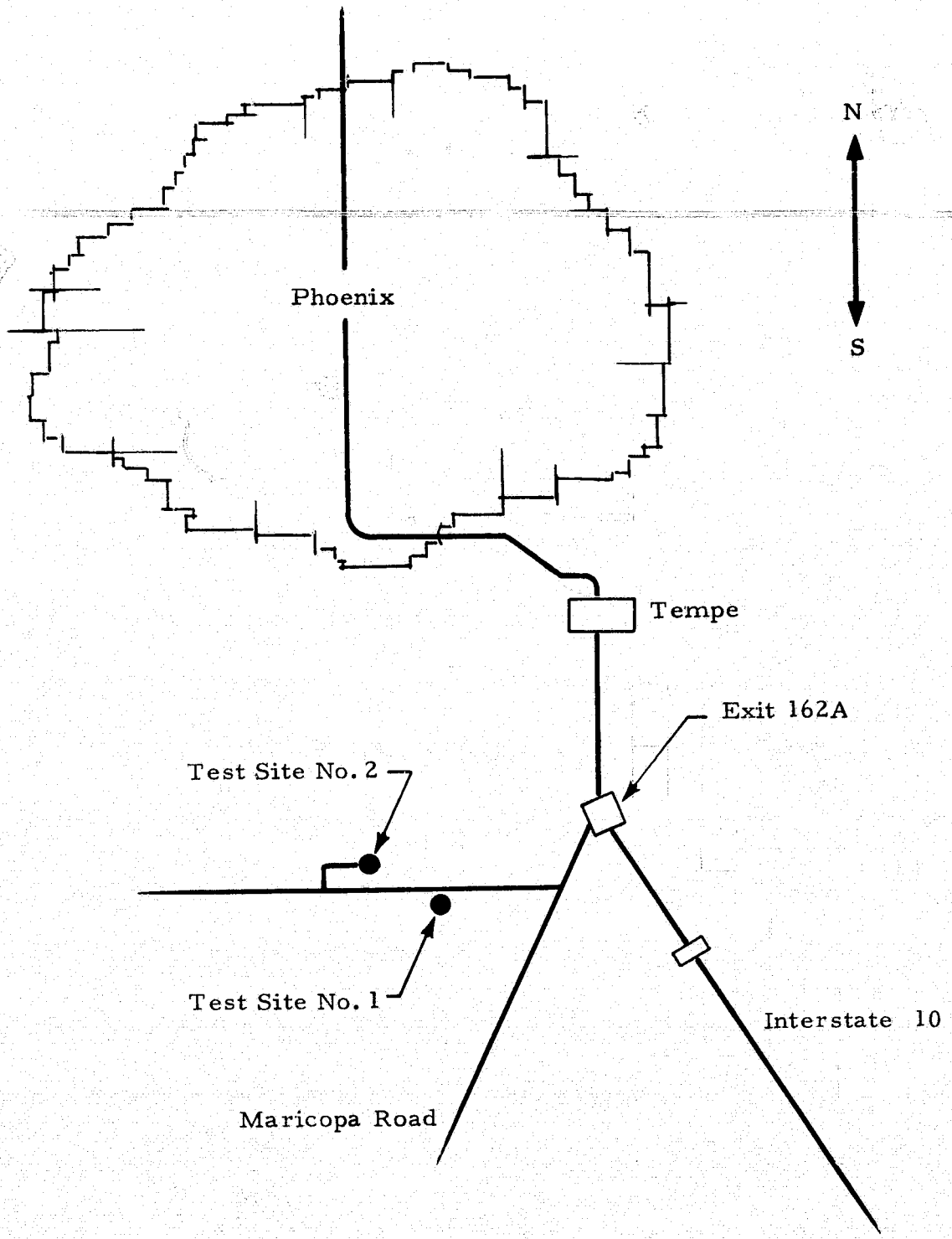


Fig. 2 - Test Site Location

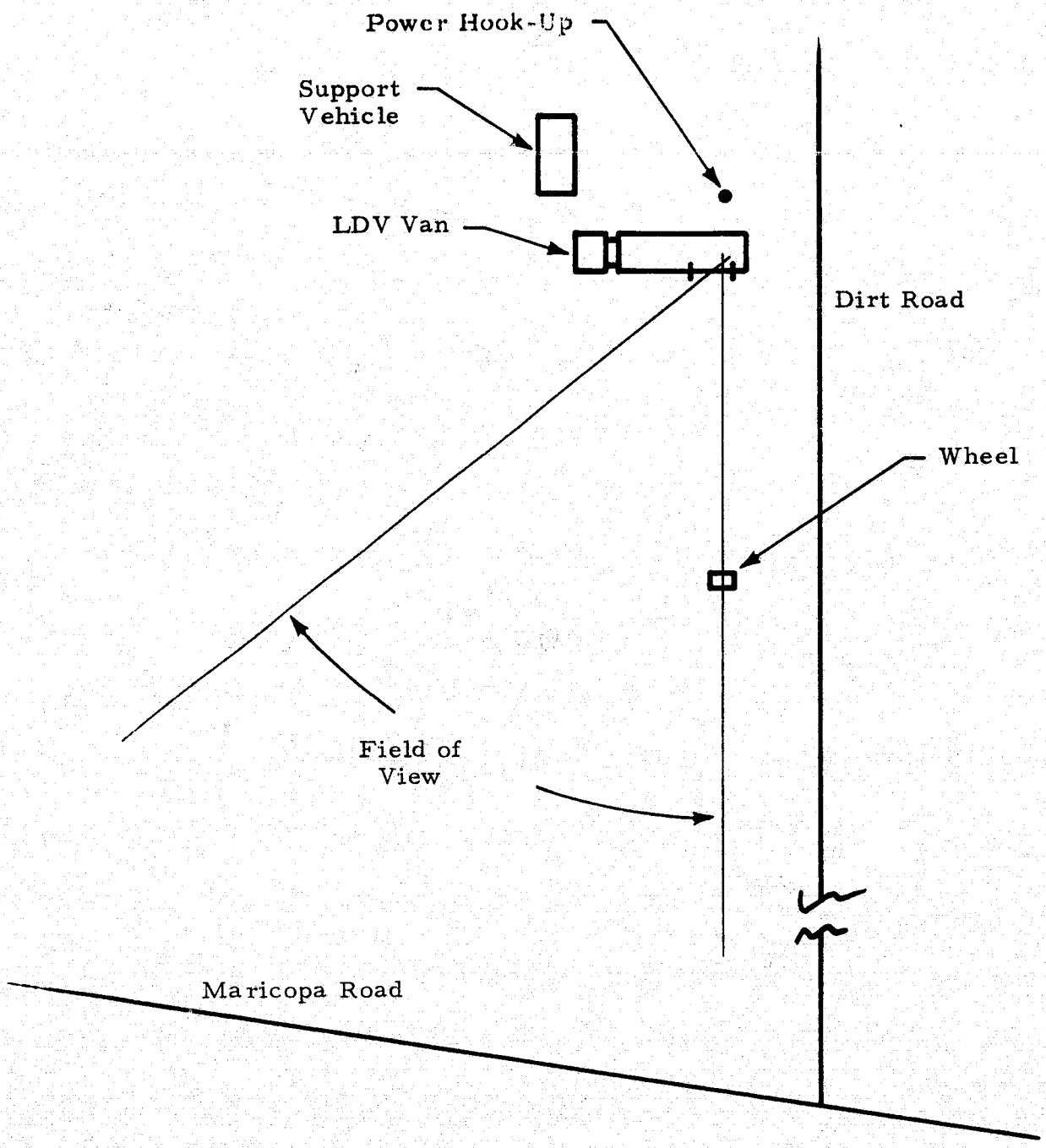


Fig. 3 - Test Site No. 1

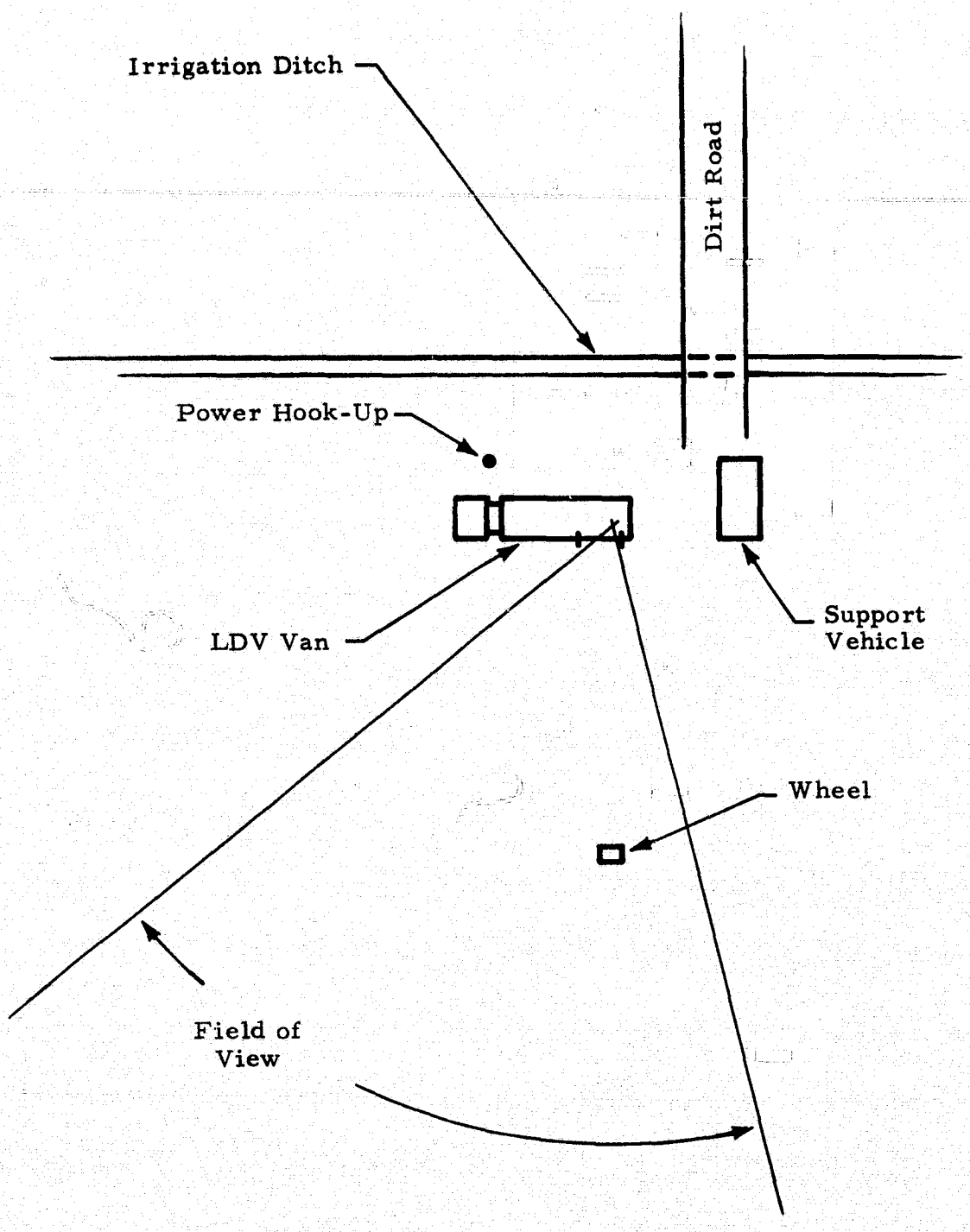


Fig. 4 - Test Site No. 2

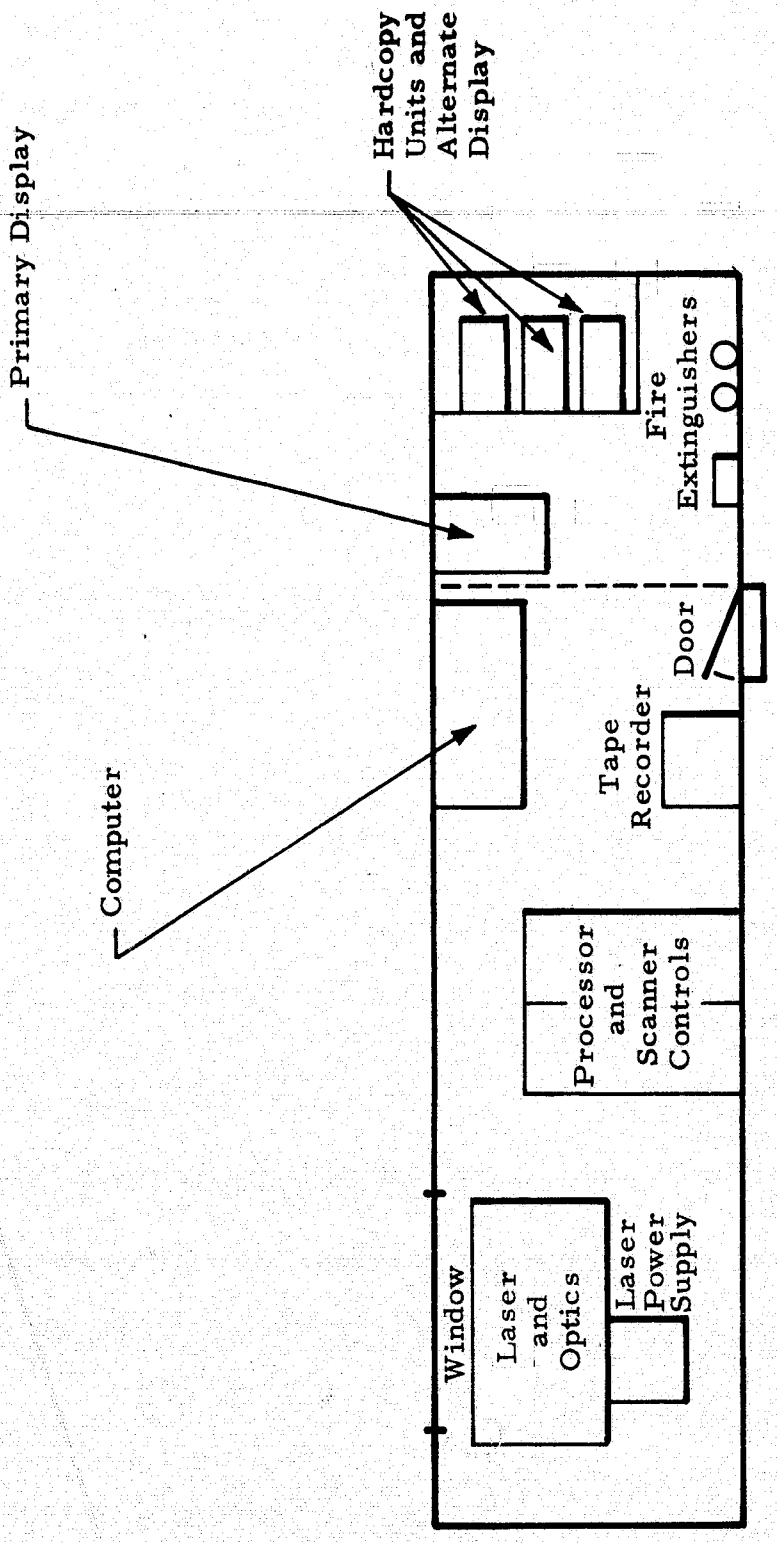


Fig. 5 - Van Layout

ENVIRONMENTAL PROBLEMS

It was apparent from the first day of van set-up at the test area that inadequate preparations had been made to handle the ambient temperature conditions. The van's level of insulation and its air conditioning system could not manage the huge heat load. This heat load can be subdivided into three parts, that due to internal heat sources (equipment), that due to radiative heating and absorbtion by the van surfaces, and that due to convective heating through the large open window in the side of the van. Due to the large angle azimuthal scanning required, the small teflon window could not be used as for previous tests. Later in the test program a large teflon window was fabricated to cover the entire opening in the side of the van. It reduced the heat load significantly. The signal-to-noise ratio was more than adequate for detection even with the insertion losses inherent in this window. To reduce the surface absorbtion, highly reflective "space blankets" were hung over the side of the van. Water was also poured on the roof and sides of the van to effect evaporation cooling. Only equipment absolutely essential was operated. To facilitate cooling of the most critical and temperature sensitive instruments, temporary plastic ducting was installed to transfer the air conditioners cold air directly over the surfaces of the equipment. The racks were sealed with masking tape to improve the effectiveness of this type cooling. A fan was also used to increase interval air circulation in the van.

Desert temperatures ranged from 85F to a maximum of 116F during the day with the normal average air temperature during dust devil activity of approximately 105F. Inside van temperatures got as high as 108F.

The data taken at the first test site was marginal for three reasons: (1) limited dust devil activity; (2) equipment malfunction due to high van temperature; and (3) personnel acclimatization problems resulting in operator

illness. Improved performance of the system at the second test site was due primarily to the higher density of occurrence of dust devils within system range and field of view. Modifications to the van, such as using the large teflon window described previously, reduced equipment temperature and prolonged operational time. To further increase effective operational lifetime, some equipment, primarily the processor, was cycled. That is, it was turned on only after a dust devil was sighted visually or on the spectrum analyzer.

By the time the second test site was established, personnel had become better adapted to the environmental extremes and were physically conditioned to better withstand the activity involved in operating the van and chasing the dust devils. During the entire test program an air conditioned recreational vehicle complete with refrigerator and restrooms was used as the office van for analyzing data, repairing equipment, eating, and escaping from the desert temperature extremes.

TEST PROCEDURE

Daily activities at Gila Bend in most instances paralleled those at Kennedy in terms of equipment set-up and operation. Upon arrival at the test site the laser was turned on, allowed to stabilize, and then an optical alignment of the system was performed (Fig. 6). A wheel signal was obtained and the range calibrated and recorded on the computer and high speed tape. The optical and data processing systems are shown in Figs. 7 and 8. The equipment was then put in the standby mode (processor off for heat reasons) until dust devil activity commenced at which time data acquisition began.

The scan parameters and mode of scanner operation were sometimes varied to obtain different types of dust devil data, i.e., occasionally, when dust devil translational velocity was small, azimuthal position was fixed and elevation and range scanning alone were used. The primary mode of operation, however, was to fix elevation and scan in azimuth and range. The range scanner was almost always utilized. Range was seldom held constant. The dust deveils were tracked visually and vocal feedback from an observer facilitated settings of the scan parameters.

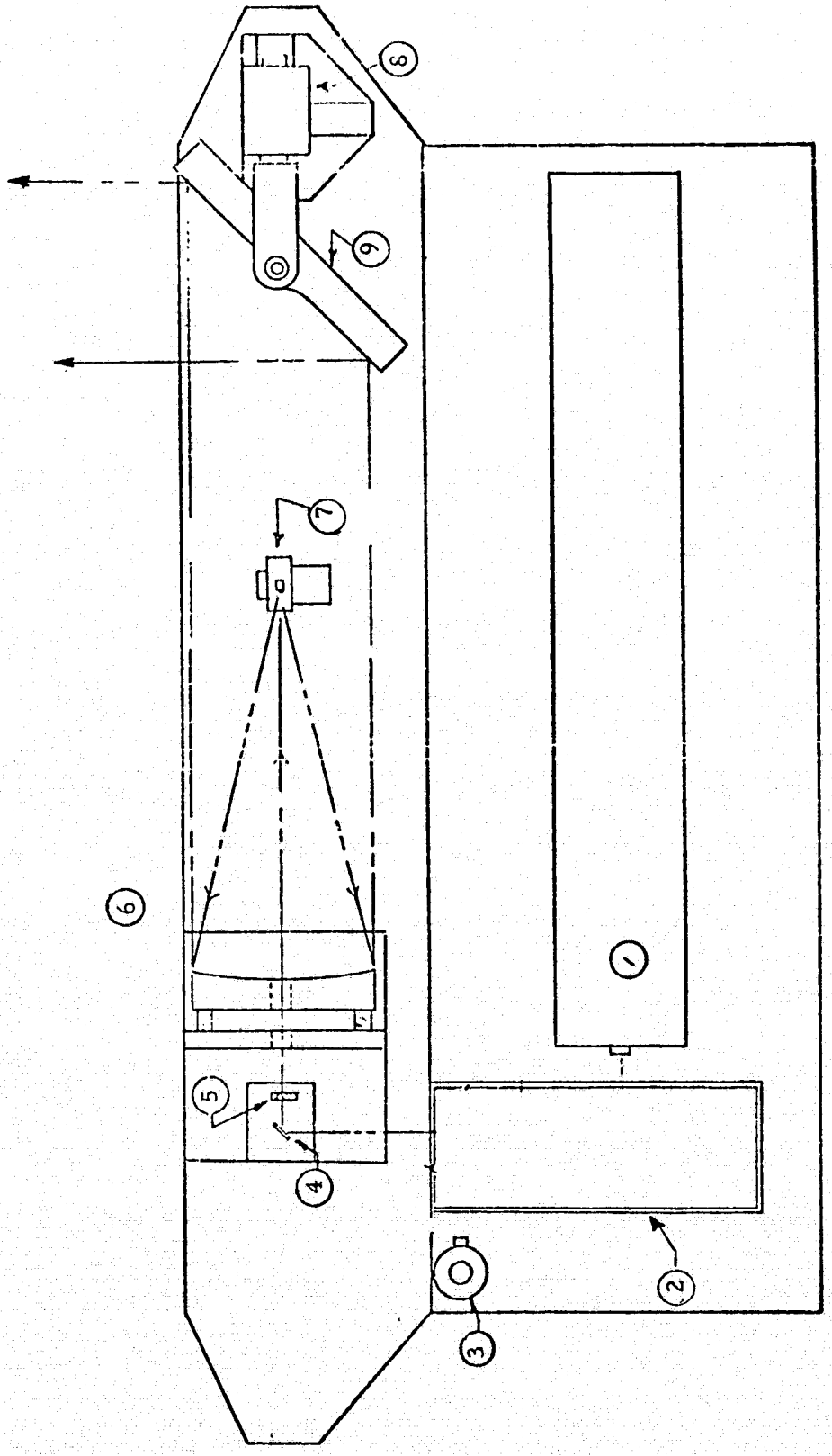


Fig. 6 - Optical System (Mirror Image of System Layout

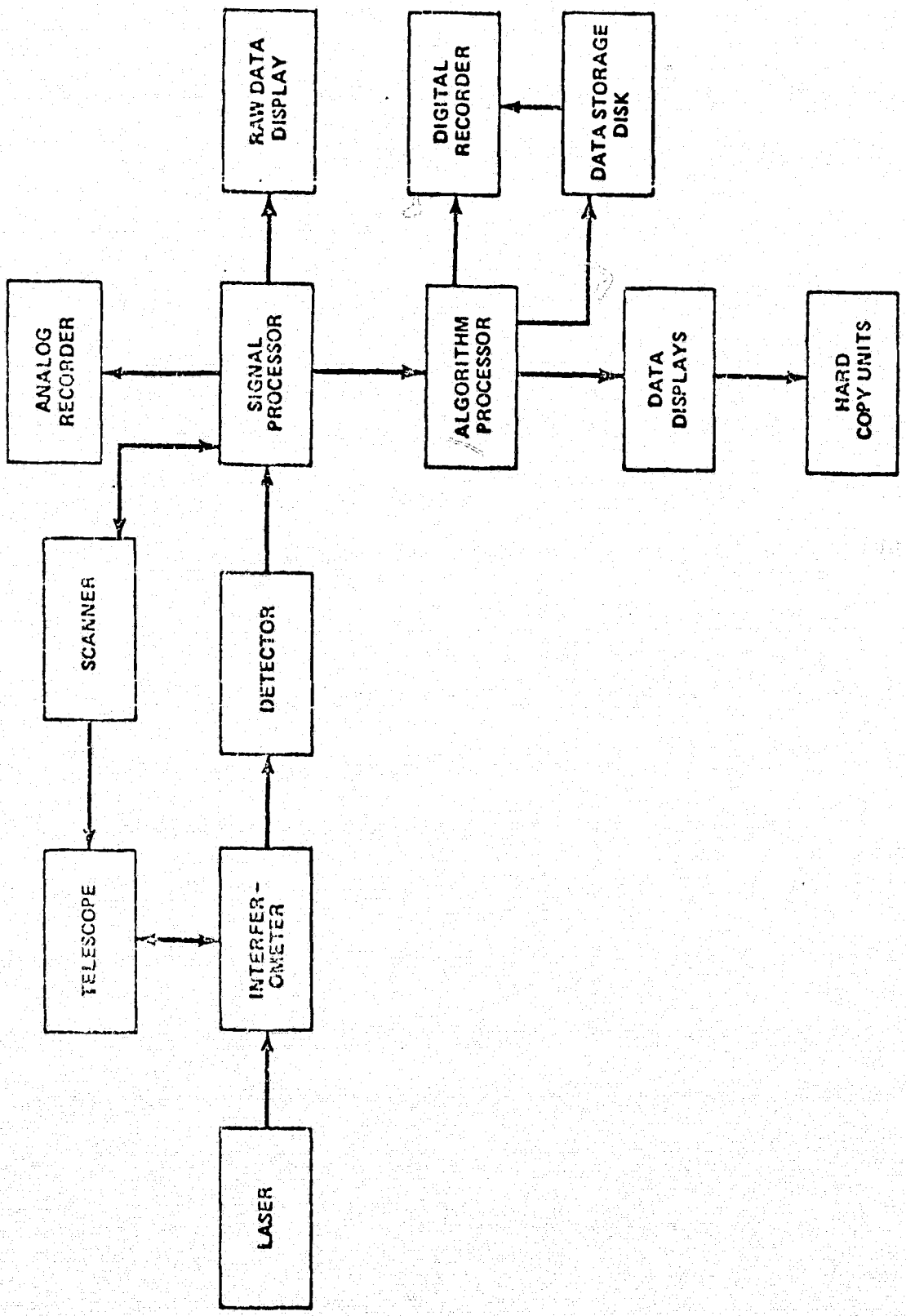


Fig. 7 - Optical and Data Processing Systems

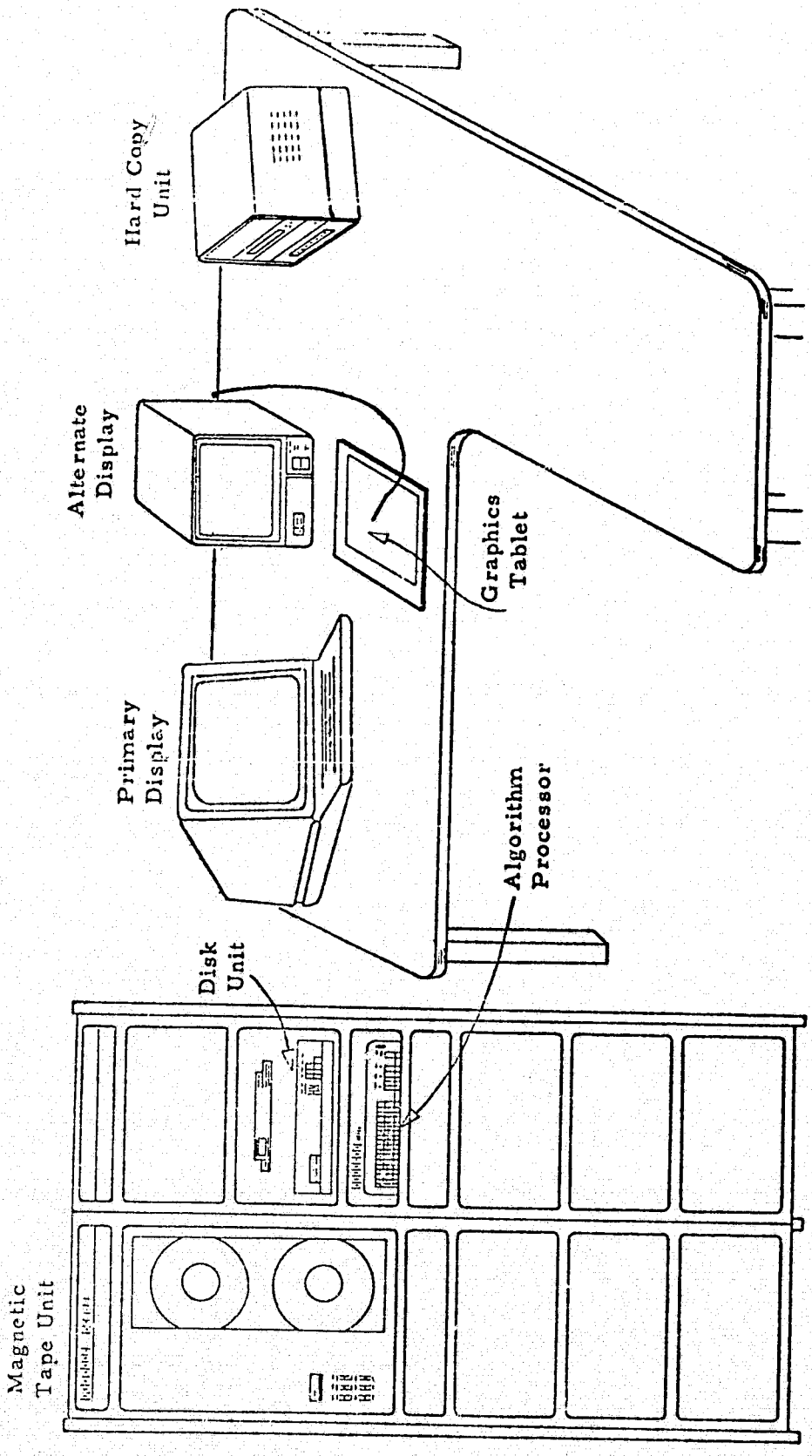


Fig. 8 - Computer System

TRANSLATED DATA

Dust devil velocity data were taken for 11 days with the last five days clearly being the most significant. The data were recorded in the nontranslated mode during the first 10 days. Prior to acquisition of the final day's data, an acousto-optic translator was inserted in the local oscillator branch of the optical train. Alignment was performed the evening before the last set of runs and completed before dust devil activity began the following day. Excellent dust devils appeared the last day and frequency excursions of several megaherz were displayed on the spectrum analyzer. Velocity data on the spectrum analyzer and processor appeared to be excellent. It should be noted that this was the first translated data ever taken of natural phenomena.

DAILY REPORTS

Daily reports were compiled listing dust devil activity, ambient conditions, and other pertinent data. These are presented both in summary form in Fig. 9 and as individual reports. A description of each test run was recorded which includes relevant information which could affect interpretation of the data, such as if the earth moving machine (referred to as "Alice" from Fiat-Allis), often present and moving across the desert, was in the scanner field of view. This dust devil commentary is included at the end of each daily report.

Location	Day	Day No.	Day Rating / Excellent Run No.	No. of Dust Devils Observed	Surface Temp. / Cloud Cover	Surface Condition	Ambient External Temp.* (F)	Interior Van Temp. (F)	Relative Humidity (%)	Wind Velocity (knots)	Wind Direction (deg)	Wheel+ S/N (dB)	Time	Testing Time Period	Problems
Test Site 1	8/10	222	Poor	0	DNA / 6	DNA	102	DNA	24	7	290	>50 (wc)	11:55	12:02 - 12:03	Van Overheating
	8/15	227	Fair	7	140F / 0	DNA	98 99 101	DNA	22 21 18	7 4 5	250 250 240	55 (wc)	11:56 12:55 13:56	12:19 13:43	Van Overheating
	8/16	228	Poor	0	>139F / DNR	DNR	100 to 104	DNA	15 to 16	5 to 11	20 to 300	55 (wc)	11:55 to 14:55	DNR	DNR
	8/17	229	Poor	0	DNR / 0	DNR	99 100 101	DNA	11 10 11	6 6 12	240 330 320	DNR	12:56 13:56 14:56	12:57 - 14:31	DNR
Test Site 2	8/19	231	Fair No. 4	15	DNA / 0,0,2	DNA	96 97 100	DNA	18 17 16	6 7 8	30 330 210	>50 (wc)	11:56 12:56 13:57	11:59 14:10	Van Overheating
	8/20	232	Poor	0	>130F / 3,2,7,7,7	Damp Dust	94 to 99	>95F	30 to 23	5 to 10	60 to 180	DNR	11:55 to 14:55	DNR	Rained Previous Night
	8/22	234	Good No. 9, 12, 15, 18	17 - 19	DNA / 0,0,0,1	Dust Powder	99 100 102 102	DNA	25 27 26 25	5 5 6 4	50 100 90 30	>50 (wc)	11:55 12:56 13:55 14:55	12:09 14:36	Van Overheating
	8/23	235	Very Good No. 7,11, 17,24	27-31	DNA / > 0	Dust Powder	99 101 103 105 104	>95F	29 26 26 24 25	6 3 5 12 12	60 110 170 310 300	>50 (wc)	11:55 12:55 13:55 14:55 15:56	11:45 - 15:23	Van Overheating
	8/24	236	Excellent No. 2,4,7, 9,17	21 - 24	DNA / 0	Dust Powder	99 102 104 105	DNA	20 19 18 18	7 9 11 12	280 310 280 270	>50 (wc)	11:55 12:55 13:55 14:55	12:28 - 14:56	Van Overheating
	8/25	237	Good No. 6,7,9, 12	12 - 15	147F / 0	Dust Powder	100 102 104 104 109F(GB)	DNA	20 20 17 20	6 9 8 10	50 260 30 260	>50 (wc)	11:55 12:55 13:56 14:55	12:15 - 14:44	Van Overheating
	8/26	238	Excellent** No. 3, 4, 5 7,9,11	10	145 - 152 / 1,3,1,3	Dust Powder	97 101 103 104	99, 108	22 21 19 18	5 4 9 5	140 290 320 220	>45 (wc)	10:55 11:55 12:55 13:55	11:32 - 13:33	Van Overheating

*Temperature data from airport measurements
Gila Bend temperature approximately 3° higher.

**Optical Frequency translator installed in system.

+Wheel at range of 122 meters.

DNA = Data not available.
DNR = Data not required.

wc = Teflon Window Closed

Fig. 9 - Test Data

RECOMMENDATIONS

If similar tests are performed again, several system improvements should be incorporated. First, the NASA van should be painted with reflective paint (silver or white) or covered with reflective material such as reflective foil to reduce absorbtion of solar radiation by the skin and resultant heating of the interior. Secondly, the air conditioning capacity should be doubled or auxilliary air conditioning units supplied. Third, a permanent but demountable teflon window should be fabricated and sealed so that leakage of hot air into the van is minimized. A useful modification to the azimuth scan mount should include a micrometer and a magnetic clutch locking mechanism to facilitate optical positioning on the wheel. An improved technique for incorporating a visual TV tracking system should be devised to allow collinear alignment of the visual and infrared optical systems. This would greatly simplify tracking of the dust vortices. Modifications to the scanner electronics should be performed to increase the tracking capability of the remote terminal. These would augment the use of the joy stick in following the dust devil in conjunction with the TV monitor.

Personnel should also be furnished with salt tablets to reduce effects of dehydration.

In conjunction with the acquisition of velocity data, a temperature profile could be obtained of the dust vortex if a passive thermal imaging system such as the AGA Thermovision were used. This equipment would produce a thermal photograph of the dust devil phenomena indicating internal thermal gradients.

SUMMARY

A joint effort by the National Aeronautics and Space Administration and Lockheed's Huntsville Research & Engineering Center produced the first detailed velocity profile data on thermally induced dust vortices. These dust devils will be analyzed and studied to determine their flow fields and origin in an effort to correlate this phenomena with the generation and characteristics of tornadoes. A continuing effort to increase mankinds knowledge of vortex and other meteorological phenomena will hopefully allow the prediction of tornado occurrence, their path, and perhaps eventually even lead to some technique for their destruction. This would result in considerable savings of life and property.

REFERENCES

1. Idzo, Sherwood B., "Tornado or Dust Devil; The Enigma of Desert Whirlwinds," American Scientist, Vol. 62, September-October 1974, pp. 530-540.

2. Ives, Ronald L., "Behavior of Dust Devils," Bulletin American Meteorological Society, Vol. 28, April 1947, pp. 168-174.

3. Sinclair, Peter C., "General Characteristics of Dust Devils," Journal of Applied Meteorology, Vol. 8, pp. 32-45.

DAILY REPORT Day Rating: Poor

On 8/10/75 (day 222), testing occurred between the hours of 12:02 and 12:03 MST for a total testing time of 0.01 hours. Total number of runs for the day was 1. Only a wheel calibration was taken. There were no excellent runs of the day. Surface conditions present for dust devil formation were good, i.e., the surface was light powder. Ambient external temperature was 102F at the airport and approximately 3^{o} higher at the Gila Bend test site. Wind conditions were 7 knots at 290 degrees. Problems included van overheating and subsequent equipment malfunction.

DAILY REPORT Day Rating: Poor

On 8/15/75 (day 227), testing occurred between the hours of 12:19 and 13:46 MST for a total testing time of 1.5 hours. Total number of runs for the day was 8. Seven dust devils were tracked by the LDV system. There were no excellent runs of the day. Average surface temperature during run time was greater than 140F. Surface conditions present for dust devil formation were good, i.e., the surface was light powder. Ambient external temperatures were 98 to 101F at the airport and approximately 3^{o} higher at the Gila Bend test site. Wind conditions varied between 7 and 5 knots over 250 to 240 degrees. Problems included van overheating and subsequent equipment malfunction.

DAILY REPORT Day Rating: Poor

On 8/16/75 (day 228) no tests were performed due to equipment malfunction. The day was spent on equipment repair and maintenance.

DAILY REPORT Day Rating: Poor

On 8/17/75 (day 229), testing occurred between the hours of 12:57 and 14:31 MST for a total testing time of 1.5 hours, however, no dust devil data was taken. Total number of runs for the day was 9. These consisted of wind measurements.

DAILY REPORT Day Rating: Fair

On 8/19/75 (day 231), testing occurred between the hours of 11:59 and 14:11 MST for a total testing time of 2.2 hours. Total number of runs for the day was 16. Fifteen dust devils were tracked by the LDV system with no more than one dust devil per run. The only excellent run for the day was run 4. Surface conditions present for dust devil formation were good, i.e., the surface was light powder. Ambient external temperatures were 96 to 100F at the airport and approximately 3° higher at the Gila Bend test site. Wind conditions varied between 6 and 8 knots over 30 to 330 degrees. Problems included van overheating and subsequent equipment malfunction.

DAILY REPORT Day Rating: Poor

On 8/20/75 (day 232), no dust devil data was obtained. Surface conditions present for dust devil formation were poor, i.e., the surface was damp powder. Problems included van overheating and equipment malfunction.

DAILY REPORT Day Rating: Good

On 8/22/75 (day 234), testing occurred between the hours of 12:09 and 14:36 MST for a total testing time of 2.5 hours. Total number of runs for the day was 18. Between 17 and 19 dust devils were tracked by the LDV system, with no more than one dust devil in all but two runs. Excellent runs of the day were numbers 9, 12, 15 and 18. Surface conditions present for dust devil formation were good, i.e., the surface was light powder. Ambient external temperatures were 99 to 102F at the airport and approximately 3^{o} higher at the Gila Bend test site. Wind conditions varied between 4 and 6 knots over 30 to 100 degrees. Problems included van overheating and subsequent occasional equipment malfunction.

DAILY REPORT Day Rating: Very Good

On 8/23/75 (day 235), testing occurred between the hours of 11:45 and 15:23 MST for a total testing time of 1.6 hours. Total number of runs for the day was 24. Between 27 and 31 dust devils were tracked by the LDV system, with more than one dust devil occurring in each of several runs. Excellent runs of the day were run numbers 7, 11, 17 and 24. Surface conditions present for dust devil formation were good, i.e., the surface was light powder. Ambient external temperatures were 99 to 104F at the airport and approximately 3^{o} higher at the Gila Bend test site. Wind conditions varied between 3 and 12 knots over 60 to 310 degrees. Problems included van overheating with resultant periodic equipment malfunction.

RUN COMMENTS – 22 AUG 75

Run 1: An anemometer calibration was attempted but the calibrate cable was disconnected inside the rack. A wheel calibration was obtained on this run.

Run 2: Recorded a small dust devil but it came in too close, perhaps, to yield good data.

Run 3: Obtained three certain hits on this one; computer down, S/N ≈ 15 dB "Alice" appeared 6 seconds before run ended.

Run 4: Saw a small one and maybe got it. "Alice" in vicinity.

Run 5: Good one at about 80 meters. "Alice" toward end of recording. This run can be classed as a dissipating dust devil type. No computer on this run.

Run 6: Tail end of a fair one. "Alice" may appear at ≈ 200 meter range. Short duration dust devil. "Alice" was not present and the dust devil was not spawned by "Alice". Cloud cover approaching. A little 6 MHz noise was observed in the spectrum. Nothing seen on processor.

Run 8: Looked good visually but didn't see it on spectrum analyzer nor on processor.

Run 9: Good one that began at ≈ 200 meter distance and was finally masked by "Alice."

RUN COMMENTS – 22 AUG 75

Run 10: Probably got only "Alice" here.

Run 11: No note.

Run 12: One dust devil generated and dissipated and immediately another generated. These were good ones. "Alice" appears ocasionally but run should provide some good tracks. Computer Run 14 contains these data. Got two different elevation data on this run.

Run 13: Got a dust devil this run but "Alice" probably masked it. Cloud cover on us after this run.

Run 14: One formed at the cloud/no-cloud interface which we recorded. Also go two more which formed later in the run.

Run 15: Very strong dust devil computer data on Run 16. Lot of scanner range turnaround noise up to 1 MHz. Got elevation data on this run.

Run 16: Arc scanned a dust devil this run. Maybe got one hit. Computer Run 17.

Run 17: This one moved out of azimuth scan range while recording. No hits observed.

Run 18: Looked good.

RUN COMMENTS – 23 AUG 75

Run 1: A wheel calibration.

Run 2: Caught a small one here but it wasn't entraining much dust. "Alice" was not present.

Run 3: Got a small one here but well developed at about 60 to 40 meters. "Alice" was not present.

Run 4: At 100 meters we had three dust devils. One of these was estimated to be 20 feet wide. "Alice" was not present.

Run 5: At ~ 120 meters out, large dust devil; no "Alice," caught it generating, saw two and picked up one as it formed.

Run 6: Small dust devil. Short lived.

Run 7: A good one close in, another at 200 meters, no "Alice." "Alice" started near end of run.

Run 8: Small one, 50 to 100 meters out. No "Alice" motion.

Run 9: Small dust devil at 100 meters, "Alice" in line with it but at greater range. Smoke bomb used.

Run 10: Small dust devil. Not easily visible. "Alice" in motion. Good spectrum analyzer but could be "Alice."

Run 11: Three different dust devils near or at wheel, ALL GOOD; "Alice" in motion; wheel range 122 meters.

RUN COMMENTS – 23 AUG 75

Run 12: Recorded a small one at wheel range and azimuth.

Run 13: Another at wheel, moderate size.

Run 14: Medium size at wheel but short lived. Two more near target. No data on these (?).

Run 15: "Alice" in motion and spawned several. Medium sized one near wheel.

Run 16: One near wheel and moving normal to azimuth scan.

Run 17: Medium one at 150 meters near wheel. Got much better. Comment was GREAT! "Alice" not in LDV field. Computer no good for this run.

Run 18: No data.

Run 19: Small one at 200 meters range.

Run 20: Computer false start. Bad run.

Run 21: Medium dust devil at 200 meters. Got "Alice" at run end.

Run 22: One at 50 to 150 meters. Recorded a small one.

Run 23: Two dust devils this run. Last one at ~ 200 meters. "Alice" started up about time of the second one.

Run 24: Good one at 200 meters. "Alice" in motion.

DAILY REPORT Day Rating: Excellent

On 8/24/75 (day 236), testing occurred between the hours of 12:28 and 14:56 MST for a total testing time of 2.5 hours. Total number of runs for the day was 19. Between 21 and 24 dust devils were tracked by the LDV system, with more than one dust devil occurring in each of several runs. Excellent runs of the day were run numbers 2, 4, 7, 9 and 17. Surface conditions present for dust devil formation were good, i.e., the surface was light powder. Ambient external temperatures were 99 to 105F at the airport and approximately 3^{o} higher at the Gila Bend test site. Wind conditions varied between 7 and 12 knots over 270 to 130 degrees. Van overheating was partially reduced but still remained a problem.

RUN COMMENTS – 24 AUG 75

Run 1: A wheel calibration.

Run 2: Picked up two dust devils near road. Good hits observed.

Run 3: May have gotten wind only on this run.

Run 4: Saw one moving right to left as you look out window. We lost it visually but apparently still picked it up with LDV. The run looked strong near end.

Run 5: Got a small one at start of the run but it dissipated while recording. Noticed some 6 MHz interference on spectrum analyzer.

Run 6: Medium size one about 200 meters away with tight core. "Alice" was not present. Got three elevation levels on this one but lost time of elevation change.

Run 7: Got large dust devil, ~ 50 feet diameter, at ~ 80 meter range. Two others then appeared, both medium quality. All were moving left to right across field. All of these were about 200 meters away.

Run 8: Got a short lived one, about 20 second duration, at 200 meters range and at 0 to 5 degrees Azimuth.

Run 9: Got a medium sized one at ~ 200 meter range, well developed.

Run 10: "Poor one not visible"

RUN COMMENTS – 24 AUG 75

Run 11: "Poor one not visible"

Run 12: First part of this run set to Run No. 11. Run number changed during run but no times recorded at the change. Probably got wind on this run.

Run 13: Got a short duration medium size dust devil on this run. Did optical alignment after run.

Run 14: Got small one at ~ 200 meters range.

Run 15: Saw one at beginning of run but it dissipated. Didn't see it with LDV.

Run 16: Got a dust devil here but also got some dust that Dr. Idso's son kicked up.

Run 17: Large diameter dust devil in distance. New large one close in. These broke up into multiple dust devils. Probably four or five long lived ones recorded. Got several elevations.

Run 18: This run is a continuation of Run 17.

Run 19: Got two large dust devils at ~ 200 meters range. At end of run, dust blew across field near the ground.

DAILY REPORT Day Rating: Good

On 8/25/75 (day 237), testing occurred between the hours of 12:15 and 14:44 MST for a total testing time of 2.5 hours. Total number of runs for the day was 13. Between 12 and 15 dust devils were tracked by the LDV system, with more than one dust devil occurring in each of several runs. Excellent runs of the day were run numbers 6, 7, 9 and 12. Surface temperature during run time was 147F. Surface conditions present for dust devil formation were good, i.e., the surface was light powder. Ambient external temperatures were 100 to 104F at the airport and approximately 3^{o} higher at the Gila Bend test site. Wind conditions varied between 6 and 10 knots over 30 to 260 degrees. Van overheating problems were reduced.

RUN COMMENTS – 25 AUG 75

Run 1: A wheel calibration run.

Run 2: Got a small dust devil on this run with the elevation at wheel height, i.e., 0 degree elevation angle; might have hit wheel during azimuth scan. "Alice" was within the LDV scan field and she was kicking up dust.

Run 3: No data were recorded for this run.

Run 4: This run was mostly "Alice's" dust which probably obscured dust devil data. "Scratch run."

Run 5: This run is of a small dust devil on the right side of the field at 200 meters range. Noticed a noise spike on the spectrum analyzer at 6 MHz. Don't know how long it has been there. The run number for this run was 4 between the times 12:37:48 and 12:38:23.

Run 6: This run is of two dust devils, one at 200 meters and obscured by "Alice's" dust wake and another at or near wheel, i.e., 0 to 5 degrees azimuth angle and 122 meters range. Got azimuth/range data at four different elevations up to 20 degrees.

Run 7: Medium dust devils at 200 meters. Overall impressions of data were "GOOD." This run was recorded with run number set at 6.

Run 8: Two dust devils recorded on this run both at ~ 200 meters. We got smoke into one of them. Scanned elevation, range and azimuth on this run.

RUN COMMENTS – 25 AUG 75

Run 9: Got three dust devils on this one. The center one was "GREAT." "Alice" was not moving for this run.

Run 10: Probably got only wind here. Spectrum analyzer showed a lot of wind-type signals.

Run 11: Got a small one here. "Alice" was kicking up some dust, too.

Run 12: Medium dust devil formed and moved left to right across field. As it progressed it turned into a real good one. "Alice" was moving and her dusty wake was entrained into the dust devil.

Run 13: Small dust devil and short lived.

DAILY REPORT Day Rating: Excellent

On 8/26/75 (day 238), testing occurred between the hours of 11:32 and 13:33 for a total testing time of 2.0 hours. Total number of runs for the day was 11. Ten dust devils were tracked by the LDV system, with no more than one dust devil per run. All data were obtained using an optical translator. Excellent runs of the day were run numbers 3, 4, 5, 7, 9 and 11. Maximum surface temperature during run time was 152F. Surface conditions present for dust devil formation were good, i.e., the surface was light powder. Ambient external temperatures were 97 to 104F at the airport and approximately 3^{o} higher at the Gila Bend test site. Wind conditions varied between 4 and 9 knots over 140 to 320 degrees. Van overheating remained a problem.

RUN COMMENTS – 26 AUG 75

Run 1: A wheel calibration run.

Run 2: Good dust devil at ~ 60 meters range and about 30 degrees azimuth. Suddenly another at ~ 90 meters and 20 degrees. This latter was thought to be spawned by "Alice." Both plus and minus frequency data observed from translated LDV spectrum.

Run 3: A good dust devil was thought to be spawned by "Alice" at 300 meters. No "hits" were seen on processor. Last part of this run is wind.

Run 4: Probably best dust devil observed in field yet. Got good translator output at both plus and minus frequency. Range ~ 200 meters moving left to right across field. Got elevation data on this one, also good photographic data. Photographic data are identified as "On Head-On Roll No. 3." Photographic data will correlate with processor data at ~ 12:45.

Run 5: Got good photographic data from inside van looking through the scanning mirror. This dust devil was the twin of the Run 4 dust devil.

Run 6: The processor run number was not advanced after Run 5 was terminated. After Run 6 was begun, run number was changed to 6 at time 13:05:21. Four elevation slices were obtained on this run.

RUN COMMENTS – 26 AUG 75

Run 7: Got a good dust devil on this run at two elevations.

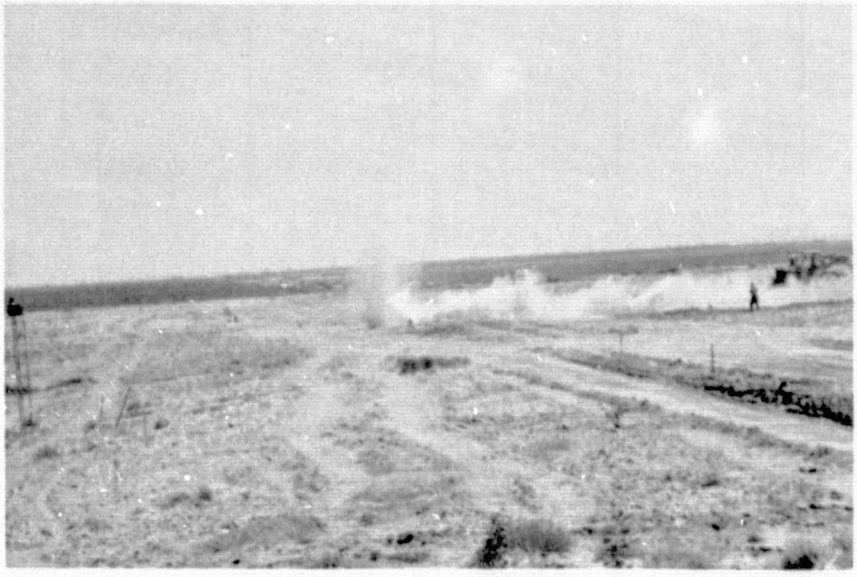
Run 8: Ground temperature at 13:17:00 was 152F. No comment on run quality.

Run 9: Very strong dust devil at 120 meters moving left to right across field. A good one! Two elevation azimuth data here.

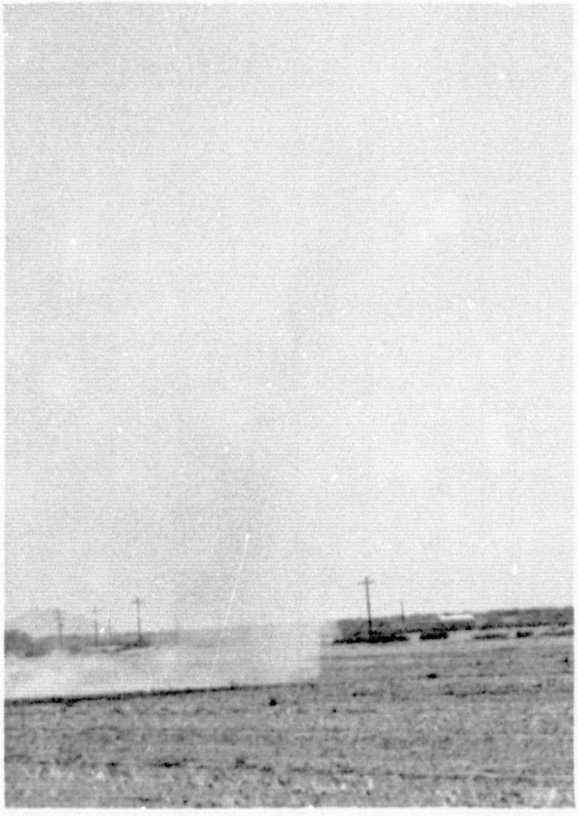
Run 10: Didn't change run number on this run, therefore the second run number 9 will actually be Run 10; use the time code for identification. This dust devil formed at 100 meters (near wheel) and moved to 10 meters or so from van. Dust devil was best developed at the close range. Overall feeling of quality was "NOT SO HOT" and it wasn't even seen on the spectrum analyzer.

Run 11: Saw this one on spectrum analyzer and it was a good one. Ranged from 100 to 50 meters.

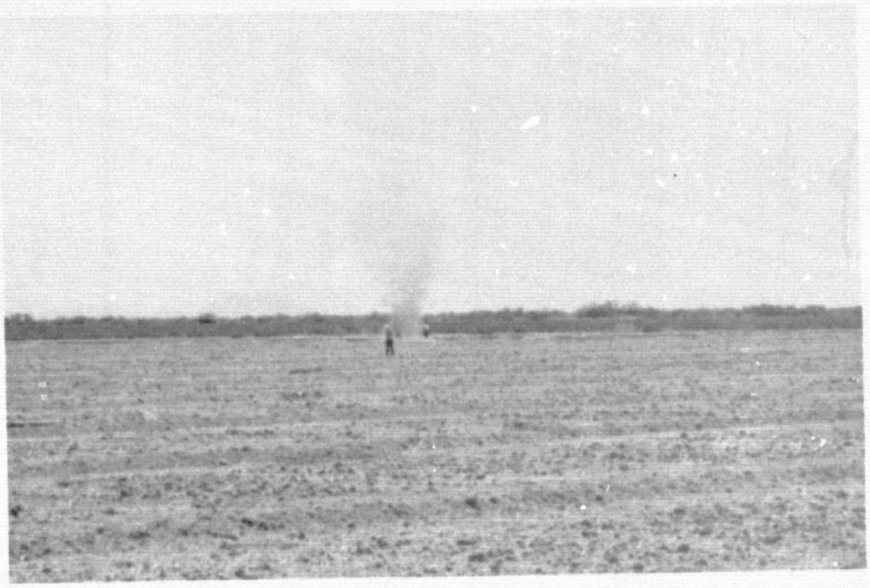
Appendix A
PHOTOGRAPHIC DATA



Tight Core Dust Devil



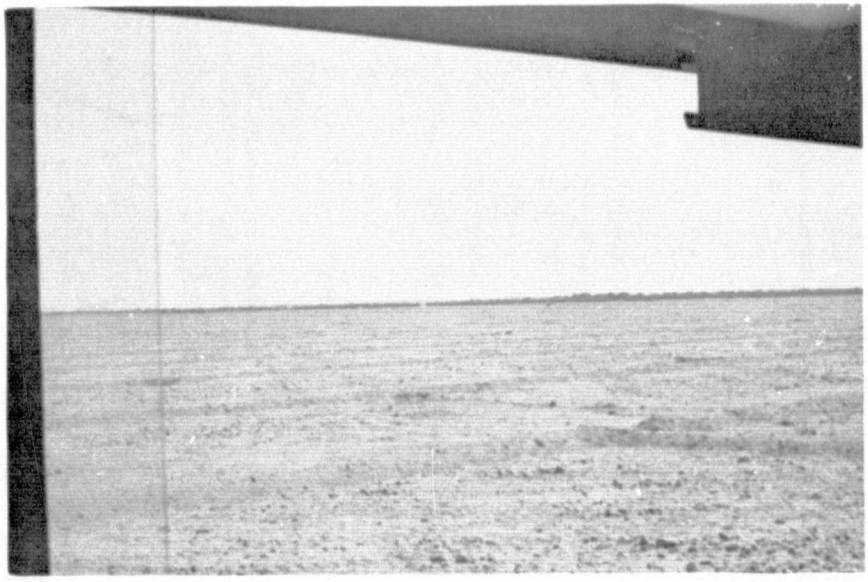
Moving Dust Devil



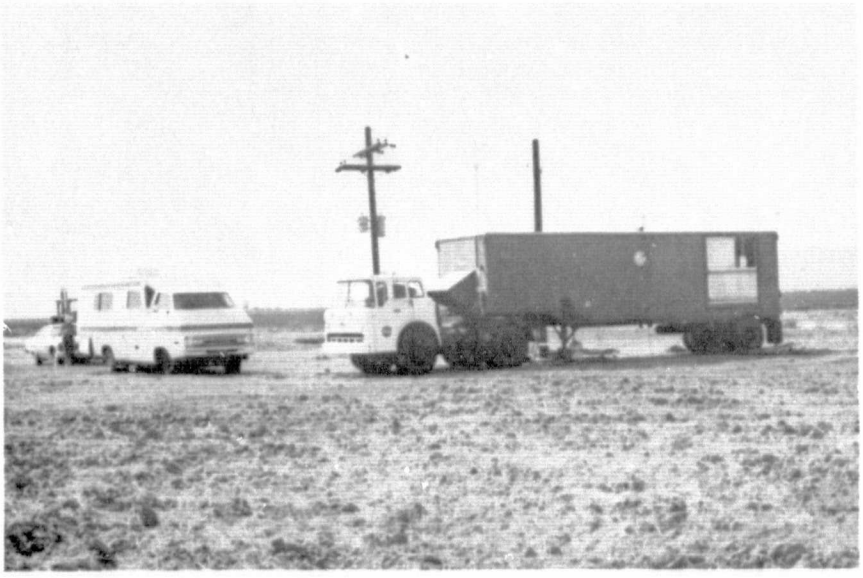
Large Dust Devil

Distant Dust Devil

Large Dust Devil in Distance



Dust Devil Viewed Through Van Window



LDV Trailer and Support Vehicle (Test Site No. 1)

Test Site No. 1

LDV Trailer

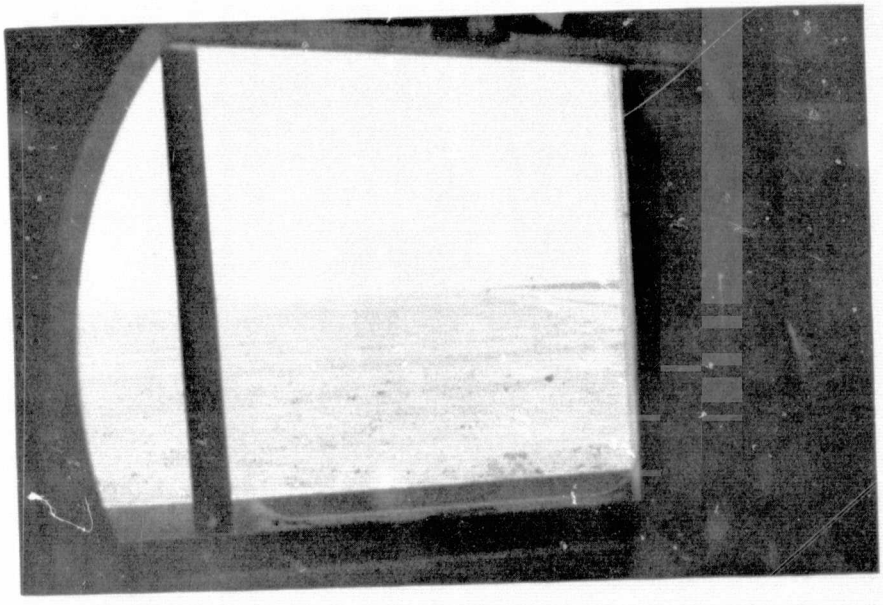
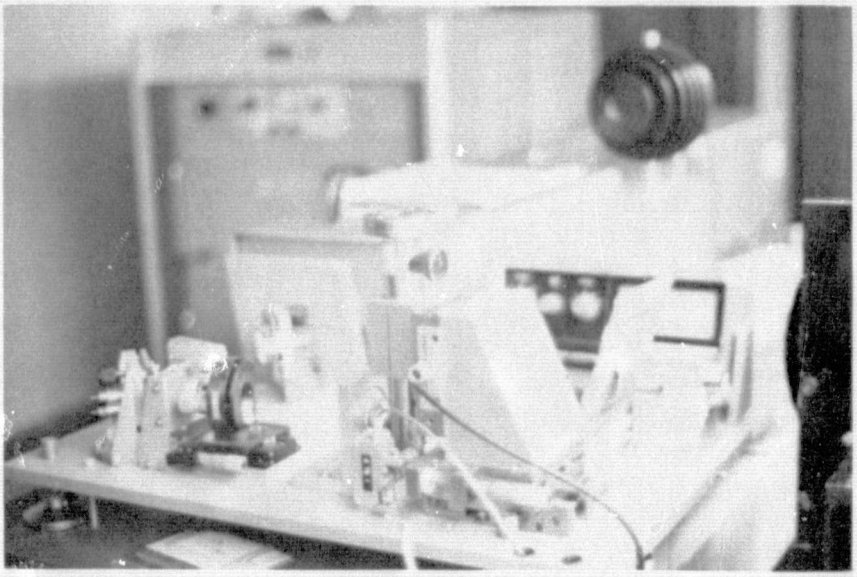


Image of Terrain Through Scanning Mirror



Optical System in LDV Trailer

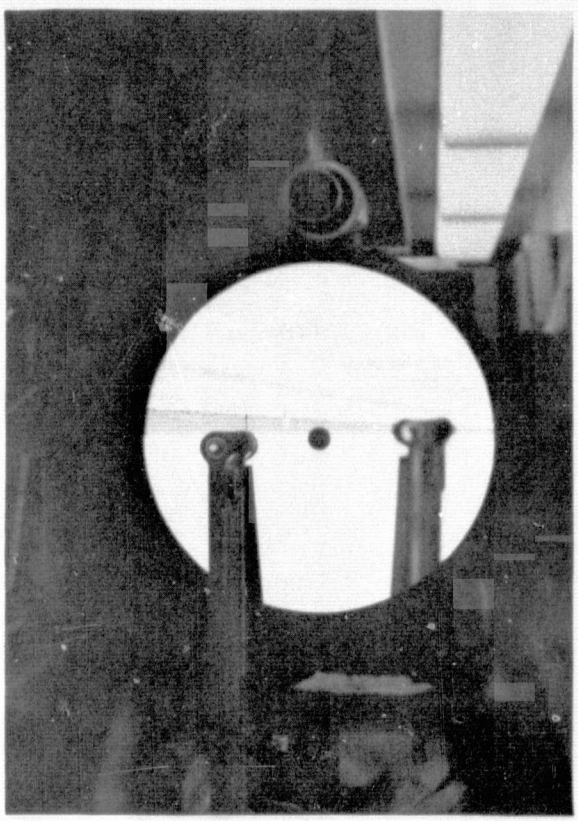
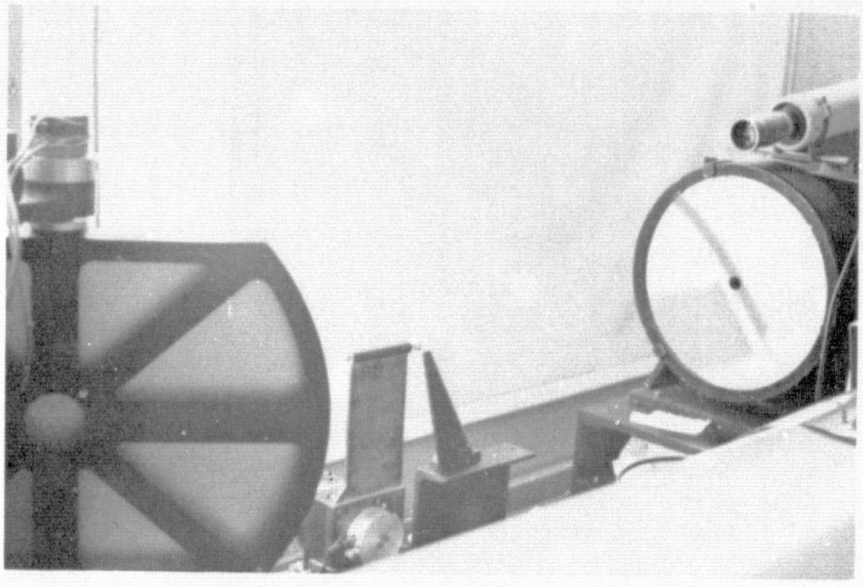
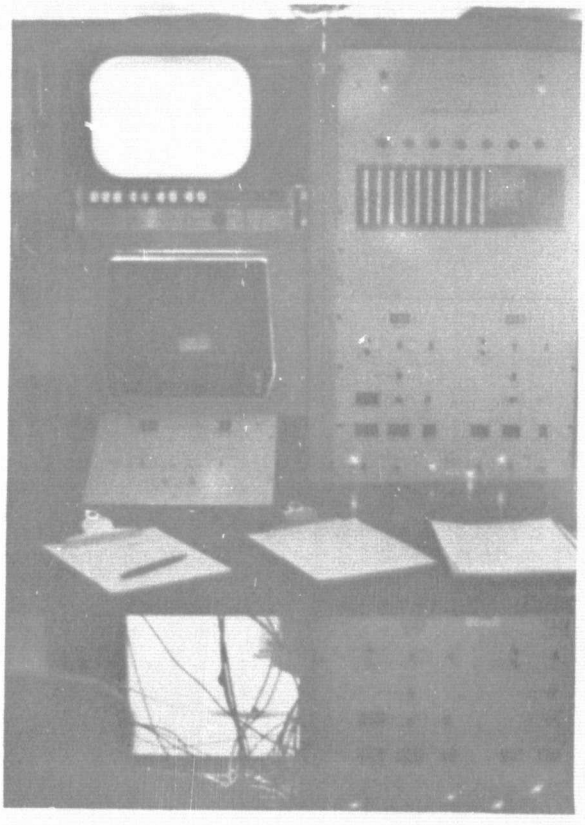


Image Through Telescope of Terrain



Telescope with Range Scanning Secondary Mirror



Electronic Control Console

Appendix B
OPERATIONAL DATA SHEETS

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location *GILA BEND*

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.
Date *08-10-75(222)*
Test No.
Sheet of

Processor & Time Code

	Time Code		General								Velocity				Display			
Run No.	Start	Stop	Input Level	Trans/Non-Trans	Vel. Coverage	Linearity	Integ. Time, msec	Amplitude Threshold	Velocity Threshold	Mode	Mode Threshold Integration	Wind Threshold	Wind Amplitude	Noise Amplitude	Scale	Velocity Passband		Reel
1001	12:02:34	12:03:00	3.8	NT	1	L	2	92	2									
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NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No. 1A
Date 8-15-75
Test No.
Sheet of

Scan Parameters

Run No.	[redacted] TIME START	[redacted] TIME STOP	Freq. (Hz)	Elevation Upper	Elevation Lower	Elevation Freq. (Hz)	RANGE [redacted] (STATIC)	AZIMUTH MAX.	AZIMUTH MIN.	AZIMUTH FREQ.
0001	12:19:19	12:20:23		3.2			300	26	15	.1
0002	12:21:06	12:22:13		↓			↓	↓	↓	↓
0003	12:23:03	12:24:34								
0004	12:26:29	12:28:05								
0005	12:43:00	12:43:41						33	05	
0006	12:55:13	12:57:49						↓	15	
0007	13:35:36	13:42:18					300		17	
0008	13:43:00	13:45:57		↓			300→400	↓	17	↓

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location: GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.
Date 8-16-75 (228)
Test No.
Sheet of

Processor & Time Code

Run No.	Time Code Start	Time Code Stop	General: Input Level	Trans/Non-Trans	Vel. Coverage	Linearity	Integ. Time, msec	Amplitude Threshold	Velocity Threshold	Mode	Velocity: Mode Threshold Integration	Wind Threshold	Wind Amplitude	Noise Amplitude	Display: Scale	Velocity Passband	Reel
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NO DATA

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location: *GILA BEND*

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.

Date *4-17-75 (229)*

Test No.

Sheet of

Processor & Time Code

Run No.	Time Code Start	Time Code Stop	Input Level	Trans/Non-Trans	Vel. Coverage	Linearity	Integ. Time, msec	Amplitude Threshold	Velocity Threshold	Mode	Mode Threshold Integration	Wind Threshold	Wind Amplitude	Noise Amplitude	Scale	Velocity Passband	Reel
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(Column groups: General; Velocity; Display)

NO DATA

ONLY WIND

LMSC-HREC TR D496754

NASA-FAA LDV WAKE VORTEX DETECTION SYSTEM

Test Location: TEMPE ARIZ.

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No. 1A
Date 8-17-75 D-229
Test No.
Sheet of

Processor & Time Code

Run No.	Time Code Start	Time Code Stop	General: Input Level	General: AGC Threshold	General: AGC Time Const.	General: Trans/Non-Trans	General: Vel. Coverage	General: Linearity	General: Integ. Time	Velocity: Amplitude Threshold	Velocity: Velocity Threshold	Velocity: Density Threshold	Velocity: Width Integration	Velocity: Mode	Display: Mode	Display: Scale	Display: Vel. Passband	Reel
CAL 01	12:57:48	12:58:28	2.3	10	S	NT	2	L	2	30	03	0	1	W1	2	3	±	
WIND 02	13:12:12	13:13:12	8	10	S	NT	2	L	2	32	01	0	1	W1	2	3	±	
WIND 03	13:48:45	13:52:49	8.5	10	5	NT	2	L	8	90	02	0	1	W1	2	3	±	
WIND 04	13:58:09	14:02:11	8.9	"	"	"	"	"	"	140	"	"	"	"	"	"	"	
WIND 05	14:03:45	14:04:46							8	110								
WIND 06	14:13:18	14:17:30							8	110								
WIND 07	14:19:00	14:23:17	9.0						8	110								
WIND 08	14:25:26	14:29 34																
NOISE 09	14:31:03	14:31:33																
10	: :	: :																

Scan Parameters

AZIMUTH

Run No.	Range (m) Max	Min	Freq. (Hz)	Upper	Lower	Freq. (Hz)	EL	Tape Recorder Channel	Identification
01	250	063	3.1	-	3.2		3.2	01	
02	250	063	2.1	30	04	.1	3.2	02	
03	"	"	"	"	"	"	3.2	03	
04	"	"	"	"	"	"	3.2	04	
05	"	"	"	"	"	"	3.2	05	
06	250	063	2.1	33	06	.1	3.2	06	
07	"	"	"	"	"	"	9.2	07	
08	"	"	"	"			3.2	08	
09	"	"	"	14	04	.1	3.2	09	
10								10	
								11	
								12	
								13	
								14	
								15	

SEE NEXT PAGE

ELEV.

ELEV.

WRONG ELEV

NOTE: 3.2° elev. = 0

Tape Information

Type Recorder: FR 2000 ☐ AR 1700 ☐ FR 900 ☐ GP 100 ☐ Other _____

Reel Number

Tape Speed

MSFC Number

Notes:

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

8/17/75

Run	Time	Elevation (deg)
06	14:14:45	5.2
	14:16:00	7.2
	14:17:00	9.2
07	14:19:00	9.2
	14:20:00	11.2
	14:21:00	13.2
	14:22:00	15.2
	14:23:00	3.2

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.

Date 8-19-75

Test No.

Sheet of

Processor & Time Code

11:28:11 - 11:28:49 WHEEL

Run No.	Time Code Start	Time Code Stop	General: Input Level	General: Trans/Non-Trans	General: Vel. Coverage	General: Linearity	General: Integ. Time / MSC Amplitude Threshold	General: Velocity Threshold	General: Mode (NOISE)	Velocity: Mode Threshold Interpretation	Velocity: Wind Threshold	Velocity: Wind Amplitude	Display: Noise Amplitude Scale	Display: Velocity Passband	Reel
0001	11:59:19	11:59:58													NOTHING
0002	12:01:47	12:03:07	8	NT	1	L	8	31	11	11					
0003	12:18:55	12:19:28													
0004	12:33:17	12:36:26													GOOD
0005	12:41:24	12:42:56													
0006	12:46:40	12:47:44													
0007	12:48:46	12:49:16													START OF ONE
0008	12:54:34	12:55:36													
0009	12:56:50	12:58:04													DUST DEVIL
0010	13:14:36	13:15:44													NOTHING
0011	13:18:11	13:18:37													PROCESSOR OVERHEATED
0012	13:35:01	13:39:32													3 DUST DEVILS
0013	13:45:13	13:49:56													DUST STORM
0014	13:56:49	13:58:12													PICKUP TURNAROUND
0015	14:06:55	14:07:20													
0016	14:09:40	14:11:29													
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NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location: GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.
Date 8-20-75 (232)
Test No.
Sheet of

Processor & Time Code

	Time Code		General									Velocity					Display	
Run No.	Start	Stop	Input Level	Trans/Non-Trans	Vel. Coverage	Linearity	Integ. Time, msec	Amplitude Threshold	Velocity Threshold	Mode	Mode Threshold	Integration	Wind Threshold	Wind Amplitude	Noise Amplitude	Scale	Velocity Passband	Reel
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NO DATA

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM
Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.
Date 8-22-75 (234)
Test No.
Sheet of

Processor & Time Code

	Time Code		General								Velocity					Display	
Run No.	Start	Stop	Input Level	Trans/Non-Trans	Vel. Coverage	Linearity	Integ. Time, msec	Amplitude Threshold	Velocity Threshold	Mode	Mode Threshold Integration	Wind Threshold	Wind Amplitude	Noise Amplitude	Scale	Velocity Passband	Ree
0001	12:09:33	12:10:03	9.5	NT	2	L	8	99	12	W		*			2	±	
0002	12:16:36	12:17:18	8					9	10								
0003	12:19:24	12:20:06															
0004	12:24:04	12:25:02															
0005	12:31:02	12:32:14															
0006	12:40:33	12:40:46															
0007	13:00:14	13:00:37															
0008	13:12:18	13:13:14															
0009	13:49:09	13:49:58															
0010	13:57:06	13:58:21															
0011	14:00:11	14:02:17															
0012	14:02:38	: :							8								
0012	: :	14:05:33															
0013	14:12:30	14:13:54															
0014	14:16:21	14:17:25															
0015	14:20:25	14:23:30															
0016	14:33:04	14:32:24	10						10								
0017	14:34:08	14:34:27															
0018	14:35:12	14:35:52															
	: :	: :															
	: :	: :															
	: :	: :															
	: :	: :															
	: :	: :															

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location: GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.
Date 8-22-75 (23d)
Test No.
Sheet of

Scan Parameters

Run No.	Range (ni) Max	Range (ni) Min	Range (ni) Freq. (Hz)	Elevation Upper	Elevation Lower	Elevation Freq. (Hz)	NOTE	AZIMUTH MAX.	AZIMUTH MIN.	AZIMUTH FREQ.
001	200	60	3.1				WHEEL			
002	300	64	↓	5			DUST DEVIL	24	3	.1
003	↓	↓	↓	↓			↓	↓	↓	.2
004	↓	↓	↓	↓			↓	↓	↓	↓
005	↓	↓	↓	↓			↓	↓	↓	↓
006	↓	↓	↓	↓			↓	↓	↓	↓
007	↓	↓	↓	↓			↓	↓	↓	↓
008	↓	↓	↓	↓			↓	↓	↓	↓
009	↓	↓	↓	↓			↓	↓	↓	↓
0010	↓	↓	↓	↓			↓	↓	↓	↓
0011	↓	↓	↓	↓			↓	↓	↓	↓
0012	↓	↓	↓	↓			↓	↓	↓	↓
0012	↓	↓	↓	7			↓	↓	↓	↓
0013	↓	↓	↓	5			↓	↓	↓	↓
0014	↓	↓	↓	↓			↓	↓	↓	↓
0015	↓	↓	↓	NOTE 1			↓	↓	↓	↓
0016	140	140	—	UNK	3.2		ARC SCAN			
0017	↓	↓	↓	UNK	3.2		ARC SCAN			
0018	140/50	140/50	NOTE 2	UNK	3.2		ARC SCAN			

Notes
(1) LOOKS LIKE ON RUN 15 ELEVATION WAS SET TO 5° FOR PART OF THE RUN, 20° FOR ANOTHER PART, AND 20° TO 5° SCANNING DOWN FOR ANOTHER PART
(2) AN ARC SCAN FOR THIS RUN BUT RANGE WAS CHANGED MANUALLY DURING THE RUN.

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.

Date 4-23-75 (235)

Test No.

Sheet of

Processor & Time Code

			General								Velocity				Display		
Run No.	Time Code Start	Time Code Stop	Input Level	Trans/Non-Trans	Vel. Coverage	Linearity	Integ. Time, Mxd	Amplitude Threshold	Velocity Threshold	Mode	Mode Threshold Integration	Wind Threshold	Wind Amplitude	Noise Amplitude	Scale	Velocity Passband	Reel
0001	11:45:17	11:46:50					8										
0002	11:58:05	11:58:55	9					22	10								
0003	: :	12:00:30						↓	↓								
0004	12:03:46	12:05:23						28	7								
0005	12:08:51	12:10:03						29	9								
0005	12:10:03	12:10:20															
0005	12:10:20	12:10:38															
0005	12:10:38	12:10:53															
0006	12:23:46	12:24:18							↓								
0007	12:31:15	12:32:27						↓	6								
0008	12:40:12	12:41:03						20	7								
0009	12:47:58	12:49:12															
0010	12:53:25	12:54:17															
0011	12:58:53	13:00:26															
0012	13:01:33	13:02:31															
0013	13:04:15	13:04:46						↓	↓								
0014	13:09:09	13:10:29						26	10								
0015	13:11:58	13:13:15						↓	↓								
0016	13:15:16	13:16:40															
0017	13:24:54	13:26:30															
0018	13:40:28	13:41:23							↓								
0019	13:45:15	13:45:42							9								
0020	14:17:28	14:19:50						↓	↓								
0021	14:24:30	14:25:37						13									
0022	14:27:21	14:30:20						↓	↓								
0023	14:43:28	14:44:55															
0024	14:46:59	14:48:36	↓				↓	↓	↓								
U,V,W	15:22:07	15:22:37															
PROP.	15:22:37	15:23:07															
CALIB	15:23:07	15:23:37															

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location: GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.
Date 8-23-75 (255)
Test No.
Sheet of

Scan Parameters

Run No.	Range (n.mi.) Max	Range (n.mi.) Min	Range (n.mi.) Freq. (Hz)	Elevation Upper	Elevation Lower	Elevation Freq. (Hz)	NOTE	AZIMUTH MAX.	AZIMUTH MIN.	AZIMUTH FREQ.
0001	200	60	2.1	5°			WHEEL			
0002	300	96						24	3	.2
0003		66								
0004		96	3.1							
0005										
0005				10						
0005				20						
0005				5						
0006										
0007	200	66								
0008	300	96								
0009										
0010										
0011										
0012										
0013										
0014										
0015										
0016							MANUAL AZIMUTH Δ	*	*	*
0017								13	3	.3
0018								23		
0019										
0020				7			MANUAL AZIMUTH Δ	*	*	*
0021										
0022				*			STEERED ELE AND AZIMUTH			
0023				5				23	3	.2
0024										
							+ 25 MPH UVW CAL			
							0.0 MPH UVW CAL			
							- 25 MPH UVW CAL			

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.

Date 8-29-75 (236)

Test No.

Sheet of

Processor & Time Code

			General							Velocity					Display		
Run No.	Time Code Start	Time Code Stop	Input Level	Trans/Non-Trans	Vel. Coverage	Linearity	Integ. Time, m sec	Amplitude Threshold	Velocity Threshold	Mode	Mode Threshold Integration	Wind Threshold	Wind Amplitude	Noise Amplitude	Scale	Velocity Passband	Reel
0001	12:28:51	12:29:50					8	13	0								
0002	12:34:44	12:36:47						24	9								
0003	12:38:51	12:40:37															
0004	12:48:25	12:50:33															
0005	12:55:29	12:57:23															
0006	12:58:30	: :															
0007	: :	: :															
0008	: :	13:01:00															
0009	13:01:38	13:03:57															
0010	13:07:46	13:09:02															
0011	13:12:35	13:14:34															
0012	13:15:46	13:16:36															
0013	13:20:25	13:22:50															
0014	13:25:16	13:27:51															
0015	13:28:30	13:29:14															
0016	14:14:00	14:15:49															
0017	14:18:55	14:20:42															
0017	14:22:10	14:23:31															
0017	14:46:25	14:49:06															
0017	14:49:06	14:49:37															
0017	14:49:37	14:50:10															
0017	14:50:10	14:50:23															
0017	14:50:23	14:50:43															
0017	14:50:43	14:51:27															
0018	14:51:30	14:52:45															
0019	14:53:15	14:56:33					↓	↓	↓								

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.
Date 8-27-75 (239)
Test No.
Sheet of

Scan Parameters

Run No.	Range (mi) Max	Range (mi) Min	Range (mi) Freq. (Hz)	Elevation, deg Upper	Elevation, deg Lower	Elevation, deg Freq. (Hz)	NOTE	AZIMUTH, deg MAX.	AZIMUTH, deg MIN.	AZIMUTH, deg FREQ.
0001	200	60	2.1				WHEEL			
0002	300	96		5				23	9	2
0003								33	3	
0004										
0005										
0006								23		
0007				23						
0008				9						
0009				3.2				33		1
0010				5						
0011										
0012										
0013										
0014			2.1/3.1				WENT TO 3.1 AT 14:15:15			
0015			3.1							
0016										
0017										
0017				8						
0017				5						
0017				7.2						
0017				9.1						
0017				11.2						
0018				5						
0019										

NASA-PAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.

Date 8-25-75 (237)

Test No.

Sheet of

Processor & Time Code

	Time Code		General							Velocity					Display		
Run No.	Start	Stop	Input Level	Trans/Non-Trans	Vel. Coverage	Linearity	Integ. Time, msec	Amplitude Threshold	Velocity Threshold	Mode	Mode Threshold	Integration	Wind Threshold	Wind Amplitude	Noise Amplitude	Scale	Velocity Passband	Reel
0001	12:15:36	12:16:00						23	7									
0002	12:19:10	12:19:56																
0003	12:31:10	12:31:52																
0004	12:34:26	12:35:26																
0005	12:37:48	12:41:34																
0006	12:41:34	12:41:48																
0006	12:41:48	12:42:10																
0006	12:42:10	12:42:29																
0006	12:42:29	12:42:41																
0006	12:42:41	12:43:10																
0006	12:43:10	12:43:22																
0007	12:47:52	12:49:[illegible]																
0008	12:56:57	12:57:58																
0008	12:57:58	12:59:34																
0009	13:00:08	13:01:06							12									
0010	13:28:57	13:30:57																
0011	13:36:08	13:56:41																
0012	14:40:28	14:42:56																
0013	14:43:49	14:44:26																
	: :	: :																
	: :	: :																
	: :	: :																
	: :	: :																
	: :	: :																

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.

Date 8-25-75 (237)

Test No.

Sheet of

Scan Parameters

Run No.	Range (ni)			Elevation			NOTE	AZIMUTH, DEG		
	Max	Min	Freq. (Hz)	Upper	Lower	Freq. (Hz)		MAX.	MIN.	FREQ
0001	200	56	3.1				WHEEL			
0002	300	96	3.1	0°	NON SCAN			33	3	.1
0003	↓	↓	↓	5°	↓			↓	↓	↓
0004				↓						
0005	↓									
0006	400			↓						
0006	↓			7°						
0006				9°						
0006				15°						
0006				20°						
0006				5°						
0007	↓			↓						
0008	300				↓					
0008	↓			15	3	2				
0009				↓	NON SCAN			↓		
0010					↓			23		
0011								↓		
0012										
0013	↓	↓	↓	↓	↓			↓	↓	↓

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.

Date 8-26-75 (238)

Test No.

Sheet of

Processor & Time Code

Run No.	Time Code Start	Time Code Stop	General: Input Level	General: Trans/Non-Trans	General: Vel. Coverage	General: Linearity	General: Integ. Time, msec	General: Amplitude Threshold	General: Velocity Threshold	General: Mode	Velocity: Mode Threshold Integration	Velocity: Wind Threshold	Velocity: Wind Amplitude	Velocity: Noise Amplitude	Display: Scale	Display: Velocity Passband	Reel
0001	11:32:10	11:33:33		T				23	2								
0002	11:38:24	11:40:23		↓				37									
0003	11:43:06	11:45:38		↓			↓	↓	0								
0004	12:41:20	12:42:36		↓			↓	↓	↓								
0004	12:42:36	12:43:09		↓			↓	↓	↓								
0004	12:43:09	12:43:33		↓			↓	↓	↓								
0004	12:43:33	12:44:18		↓			↓	↓	↓								
0005	13:02:46	13:03:36		↓			↓	↓	↓								
0006	13:04:29	13:04:59		↓			↓	↓	↓								
0006	13:04:59	13:05:21		↓			↓	↓	↓								
0006	13:05:21	13:05:49		↓			↓	↓	↓								
0006	13:05:49	13:06:18		↓			↓	↓	↓								
0007	13:07:08	13:07:28		↓			↓	↓	↓								
0007	13:07:28	13:08:36		↓			↓	↓	↓								
0008	13:10:04	13:11:09		↓			↓	↓	↓								
0009	13:20:45	13:21:50		↓			↓	27	3								
0009	13:21:50	13:22:04		↓			↓	↓	↓								
0010	13:24:49	13:26:20		↓			↓	24	4								
~~0011~~	~~14:32:10~~	~~13:33:24~~		~~↓~~			~~↓~~	~~↓~~	~~↓~~								
0011	13:32:10	13:33:24		↓			↓	↓	↓								
	: :	: :															
	: :	: :															
	: :	: :															
	: :	: :															

NASA-FAA
LDV WAKE VORTEX
DETECTION SYSTEM

Test Location
GILA BEND

LOCKHEED MISSILES & SPACE COMPANY, INC.
HUNTSVILLE RESEARCH & ENGINEERING CENTER

FLIGHT TEST DATA SHEET

System No.
Date 4-26-75 (238)
Test No.
Sheet of

Scan Parameters

Run No.	Range (mi) Max	Range (mi) Min	Range (mi) Freq. (Hz)	Elevation Upper	Elevation Lower	Elevation Freq. (Hz)	NOTE	AZIMUTH, deg MAX.	AZIMUTH, deg MIN.	AZIMUTH, deg FREQ.
0001	200	61	3.1				WHEEL			
0002							D.D.			.1
0003	151			5°	N.S		WIND	33.1	3	
0004	450	96		5°			D.D.			
0004				9°						
0004				7.1°						
0004				5.0°						
0005				15.0°	5°	.2				
0006				5.0°	N.S.					
0006				8.1°						
0006				15.0°						
0006				20.0°						
0007				20.0°						
0007				5.0°						
0008				5.0°						
0009				5.0°						
0009				10.0°						
0010										
0011										

Notes N.S. SIGNIFIES A NON-SCAN MODE
D.D. SIGNIFIES DUST DEVIL DATA